whose ravages so fearfully contribute to abbreviate the span of human existence, we cannot, as members of an enlightened and philanthropic profession, fail to be impressed with the exalted nature of every effort, the tendency of which is to advance us a step in the pathway of useful discovery. The inquiry is a noble one, and will conduct the inquirer to a fertile field; but he must go forth prepared to break the surface.

This article has unavoidably partaken of a discursive character; many highly interesting details have been altogether omitted, and those noticed have been introduced regardless of system or order; but if the line of inquiry which I have attempted to indicate has been made obvious, more especially if the claims which I am persuaded should be allowed it have been in the least advanced, my main object has been achieved: for I verily believe, and willingly commit to record the opinion, that if in the progress of medical discovery, the great desideratum—the successful treatment of tubercular consumption—which has so long and so effectually baffled the champions of the noblest science relating to earthborn things should yet be attained, the solution of the mysterious problem will not be due to the stethoscope, auscultation, or percussion.

Art. VI.—*Inquiry into the Physiology of the Organic Nervous System.*

By Isaac Casselberry, M. D., Evansville, Ind.

Every material of the universe consists of *matter in motion*. This motion is termed *force*. Heat, light, and electricity are only states of matter. When a bar of iron is heated, its molecules are thrown into undulations which are propagated with definite form and character to contiguous particles of atmosphere, and from them to the hand or thermometer.

The motions of light, electricity, sound, colour, &c., are entirely analogous to those of heat, and the manifestations which they all present are dependent on the form of the substance from which they are evolved.

The causative motions must not be supposed to involve any transference of particles from point to point, which is the kind of motion most commonly recognized by our senses. There is a wide difference between the motions of a wave and the motions of the particles among which it is passing.

When we disturb the middle of a watery surface, circular waves are propagated from the centre to the circumference of the surface. A feather, or other light body placed upon the waves, is not drifted forward with them, but it remains motionless. We know nothing of matter itself; all our knowledge of it is confined to its motions. There is no such a thing as a vacuum; the term has only a relative import. A substance is heavy or light, hot or cold, wet or dry, green or red, according to the form of motions

which emanate from it, and impress our senses. The laws and phenomena of motion are, therefore, the fundamental elements of all inquiry.

The various motions of matter are not only analogous, but mutually convertible. Prof. A. D. Bache has shown conclusively that light may be converted into heat; colour alone does not modify the radiating power of a surface. Expose cloths of the same texture, but of different colours, on a surface of snow to the action of sunlight, and the quantity of heat absorbed is the same for all the pieces. But the quantity of light absorbed by the black cloth is evidently the greatest, because none is reflected; and it is the black cloth which always sinks the deepest into the snow. More heat has, therefore, gone from the under surface of that cloth into the snow than from any of the others, although no more heat was received by it as heat. What has become of the light, and where did the increased heat come from?

The light cannot be said to be *latent*, because by no possible means can it ever be reproduced from the cloth. The undulations of light must have passed into the cloth, modified by its organic texture, and it was absorbed by the snow as undulations of heat.

The original heat from the sun received increments from each cloth, but most of all from that which reflected no light; because all the light passing into that one was converted into heat.

Friction, which is only impeded motion, is productive of all the physical forces. When two smooth surfaces are rubbed together, heat is evolved; if there be any inequality, electricity is evolved; and if the motion apparently lost in resistance be very considerable, light is also generated. Now this motion is not lost or annihilated by friction, but it has passed into the forms of heat, light, and electricity; for the quantity of these produced depends exactly upon the degree of motive force expended in the friction.

This theory applied to the facts of caloric evinces the fallacy of the obscure doctrine of its *latency*. Boiling water and steam are always at the same temperature, 212° F. But steam in being condensed into water gives out 950° F. of heat; that is, it requires the mechanical force of 950° F. of heat to convert water into steam; and, by condensation, this force is again returned to its equivalent condition as 950° F. of heat. In the conversion of water into steam, the heat is, therefore, changed into mechanical force.

Heat also produces electricity and chemical actions; and both may be increased or diminished by the increase or diminution of the caloric, which is undergoing the change into these new forms of force.

Chemical affinity produces heat, light, electricity, magnetism, and mechanical power. This is strongly exemplified in the explosion of gunpowder.

In all these cases, the amount of new force generated is exactly proportional to the rapidity and extent of the chemical action.

The transmutation of electricity into heat, light, chemical affinity, and mechanical power, is so common and obvious, that philosophers regard that agent as the predominant element in nature. While the forms of matter are

continually changing, the matter itself is persistent. None is ever created, and none is ever lost. The motions of matter are, however, in a state of incessant mutual transmutation. Every organized being, vegetable or animal, gives back to inorganic matter, not only the material, but the forces which it received from it. The forces of nature are motions of matter capable of being submitted to mathematical analysis, and mutually convertible into each other. The laws by which heat and light are radiated, reflected, absorbed, and polarized are identical.

Faraday has demonstrated that the five species of electricity—the common, the voltaic, the magnetic, the thermal, and the animal—are identical. That great electrician has also demonstrated the identity of electricity and magnetism, to the entire satisfaction of all philosophers.

The influence of heat on magnetic bodies, and of light on the vibrations of the compass, completes the link of the occult chain which binds all the forces or motions together. These facts demonstrate the *unity of forces.*

Those physiologists who do not recognize the convertibility of forces have been obliged to affirm, that the *vital force* exists in a dormant condition in all matter capable of becoming organized.

In the lowest form of the vegetable germ-cell, heat and light are required as specific stimuli, prior to the commencement of development. The rate and extent of development are exactly proportioned to the amount of luminous and calorific forces appropriated.

According to Boussingault, the same annual plant in arriving at its period of development, and in going through all the processes of flowering and maturing its seeds, everywhere receives the same amount of solar light and heat, whether it be grown at the equator or in the temperate zone; its whole period of growth being in a precisely inverse ratio to the quantity it received in any given time, and its rates of growth consequently in a direct ratio.

Hence, it appears that the organizing force of plants bears a relation of equivalence to the light and heat which act upon them. The agency of light is particularly directed to the fixation of carbon in the vegetable structure. The amount of carbon fixed is always in accordance with the degree of illumination it receives. The maturation of the seeds of plants, and the eggs of insects, may be at pleasure retarded or accelerated by the mere regulation of temperature. Dr. Edwards has made some experiments upon the tadpole, which show the agency of light in organization.

When carefully excluded from the sunlight and well supplied with aerated water and food, they grow to twice, and even thrice their size as tadpoles. But they underwent no change into frogs. Mr. Higginbottom's experiments confirm those of Dr. Edwards. According to Dr. Draper, the chemical rays or undulations excite or determine the arrangement of the molecules into particular groups, so as to produce developments. The inference from these experiments, and a vast mass of similar facts which might be adduced here, is, that the *external* forces of nature, particularly light and heat, passing into

organized structures, become converted into *new manifestations* of force, which are termed assimilative, organizing, reproductive, &c. Chemical action and mechanical motion constitute the fundamental basis of all these processes. By the former an extensive range of new compounds is generated, such as have never been imitated in the laboratory of man. Light and heat are the forces, which, acting through the vegetable and animal cells as their material substratum, produce these new chemical attractions, which determine the formation of the new compounds.

In other words, a portion of the force known as heat and light ceases to exist as such, and is manifested in a modified form, as chemical affinity, which again, in the act of decomposition, is reconverted into heat and light.

All the external forces are in this manner transformed by the organic nervous force into the different organic forces or processes manifested in the human organism.

Vitality in man is produced and maintained by the organic nervous system. The highest production of vitality in any individual, plant, or animal, is the production of an organic substance or being, capable of beginning in a new individual the wonderful circle of phenomena which characterize the life of a parent. There are two incident actions necessary to accomplish this, the elaboration of an ovule or organic cell by the female, and the impinging upon that cell of another cell, the spermatozoon, secreted by the male. The spermatozoon transfers the incipient force to the organic processes of the ovule in which it produces a series of transformations of the parent cell, which results in embryonic development.

The spermatozoon is a secretion; it is vitalized matter in motion.

As the pollen is the specific form for the embodiment and transference of organic force from plant to plant, so is the spermatozoon that of the organic nervous force of animals. The spermatozoon presents the anatomical appearance of a nerve vesicle and its filamentary appendage. It is not improbable that the infinitesimal motions going on in its globular portion have the precise mathematical character of those which occur in the vesicular, so that not only physical peculiarities, but *hereditary* diseases, are transferred *materially* from parent to offspring. The organic nervous centre is the first tissue formed in the embryo.

Marchesseaux, in his *Nouveau Manuel d'Anatomie Generale*, says, that, at this stage of development, we notice a fact which confirms with irresistible power the doctrine of the centrepal succession of organs. Each one of these germinating sacks consists of three layers or laminæ, differing in nature. Of these, the external or *serous* always begins to organize first; and from it arise successively the spinal cord, brain, vertebra, cranium, the organs of sense, and their dependencies. When the external lamina has thus sketched out the forms of the organs of animal life, the middle or *vascular* lamina commences in its turn, and in a similar manner marks the outlines of the peripheral vessels, the venæ cavæ, the aorta, and the heart. Up to this period,

the internal or *mucous* lamina has been inactive; but now its movements begin, and we see it successively delineate the alimentary canal, the lungs, the liver, the spleen, &c. This order is invariable; universally does nature proceed in this manner. This is given as a part of the *resumé* of the vast embryological researches of Serres and St. Hilaire.

Prof. Agassiz, in his lectures on comparative embryology, accords with this description.

Ackermann, Rolando, Blumenbach, Gall, and others, state that the solar ganglion is the tissue or part first formed in the fœtus. What Blumenbach, Elliotson, and other physiologists claim for the *nisus formativus*, is here claimed for the solar ganglion, the centre of the organic nervous system.

Dr. Carpenter, in common with other distinguished physiologists, says, that all the phenomena of cell-growth are explicable on the hypothesis of the *convertibility of forces.*

The more obvious motions of the animal are evidently dependent upon the nervous systems. Everything to which the term motion can be applied, in man and animals, belongs to the nervous apparatus. Both the voluntary and involuntary muscular contractions are a continuation of the organic nervous force. The simplest and most universal of these motions are a series of cellular transmutations usually known as capillary attraction and ciliary motion. These perform an important part in the changes of all organized beings. Matteucci has demonstrated them to be chemical attraction.

Both this attraction and chemical affinity can be shown to be remote modifications of heat. Capillary attraction can be accelerated or retarded, by increasing or diminishing the temperature. The correlation between electricity and heat has been demonstrated. Becquerel asserts that electricity is a constant attendant upon the phenomena of capillary attraction. Ciliary motion, although seldom discovered except with the microscope, is common to plants and animals. Nothing seems absolutely indispensable to their activity, but the integrity of the epithelial cell to which they are attached.

Dr. Carpenter thinks that this ciliary motion may be a partial expenditure of the organic force derived by *convertibility* from the solar emanations. He considers this view to be remarkably confirmed by the fact that, in the history of the zoospores of the algæ, we have two distinct periods, one of ciliary motion and the other of growth and multiplication. So long as the ciliary action continues, no further organic changes take place in them; but so soon as this ceases, and they become stationary, they begin to exercise chemical transformations and to grow and multiply as cells. In the higher order of living beings, ciliary motion is the expression of the excess of organic force in the subjacent tissues. The contraction of involuntary muscles is independent of any connection with the cerebral and the true spinal nervous systems. The *inherent irritability* of muscular fibre, as taught by Haller, is still the prevalent doctrine of the schools. But if the mutual convertibility of forces has any foundation in nature, this *inherent* or *latent* irritability is as

unphilosophical as latent heat and light, or latent force of any other kind. The force which produces muscular contractions is not educed *from* the muscles, but it is *transferred* to them. The cells which constitute muscular fibrillæ can undergo no modification but shape; they exercise no power of chemical transformation. They undergo no histological changes, and appear to be entirely destitute of the power of self-multiplication. The expenditure of their organic nervous force in the single act of contraction involves their death and disintegration; their renewal is accomplished by the production of new cells from the myolemma, which itself possesses no contractility. The force which produces the contraction of the muscular fibrillæ must therefore always be *transferred* to them by the organic nervous branches. It is for the conservation of this nervous system that the anatomical and histological tissues are added to it as embodiments and properties. It is the seat and source of their vitality. They are regulated and maintained in co-ordinate life by its force.

Neurine, which is the technical name for nervous matter, is of two kinds, the *vesicular* and the *tubular*. The peculiar power of the nervous system lies in the vesicular portion; it generates force, while the tubular only conducts it. Solly and others have aptly compared the vesicular neurine to the secreting cells of a gland. It eliminates a force from the blood as the nucleated cells of the liver or testicles eliminate new and different organic materials from the same substance. The tubular neurine has been compared to the efferent ducts of the glandular structures, because it is designed to convey something from one point to another. The creation of organs in the embryo is precisely identical with the nutrition of organs in the adult. The original organic cell of the ovule receives the organizing force of the spermatozoon, and reproduces from the surrounding amorphous matter, by assimilation, a vast number of similar cells with their filamentary appendages of tubular neurine. These occupy the points which will afterwards be occupied by the various peripheral organs. The cells are provisional centres, and act independently. They eliminate organic nervous force from the maternal blood, and construct the tissues at the terminus of their tubes or nerve-trunks, just as in the adult body. The growth or extension towards the central axis is effected by the successive addition of cells like beads attached to beads; the last bead or cell formed being the provisional centre of the thread, the remaining cells running together by coalescence into tubes, as in the case of the arteries.

Thus each nerve is separately constructed, and they all converge simultaneously towards the solar ganglion, the centre of the organic nervous system. They do not, however, reach that axis simultaneously, for they may be imperfectly developed; the original order of the different formative processes may be perverted or suspended. A total arrest of development would give us no centres; it would be death. A partial arrest, however, might give us a spinal cord and no brain, or a brain and no spinal cord. The thoracic

viscera may be imperfectly developed, as evinced in an interesting case published by Prof. Byford. In the remarkable case cited by Dr. Hall of a fœtus born without either brain or spinal cord, yet perfectly developed, we have a very satisfactory proof of the manner in which the organic nervous system is first formed, and of its independence of the cerebral and true spinal nervous systems. In the very interesting case of acephalous monstrosity published by Mr. Lawrence, in which the brain only was wanting, we learn that all the organic and true spinal functions were performed with integrity. The existence and function of provisional cells or centres, which disappear entirely when their use is fulfilled, are well recognized in general and special physiology. The motion of the blood begins in the vascular area of the middle lamina, some time before the formation of the heart. This motion is from the periphery towards the centre, which is afterwards occupied by the heart. Nothing so fully and consistently accounts for this motion as the transmutation of the organic nervous force from a provisional centre. These provisional cells are to the capillaries what the cardiac centres are subsequently to the heart itself. "There can be," says Carpenter, "no reasonable doubt that the production of nerve force in the central organs is dependent upon the development of the peculiar cells constituting the ganglionic or vesicular neurine; and, as already remarked, the progress of physiological inquiry seems to justify the belief that either cells or cell-nuclei are agents in the origination of nerve-force at the peripheral extremities of the nerve fibre." The spermatozoon is a secretion from the testes of the male; it is organizing matter in motion, which is *force*. This force is communicated to the female ovule, which is organizable. An uninterrupted series of cellular formations and transformations produced in the organizable matter or force of the ovule results in the development of the embryo. When matured, the relation between the mother and the embryo, or fœtus, is dissolved by the process of parturition. The organic functions of the infant retain the organizing force; but the organizable matter is no longer supplied by the maternal blood. It must be derived from external sources, and introduced into the infantile stomach.

The organic nervous system may be divided into *three* series: the *first* connects with the nerves of the cephalic domain, whether cerebral or true spinal, and passes with them to the muscles and the viscera; the *second* plunges directly into the viscera; the *third* embraces the arteries and veins, and forms a plexus around their tunics, surrounding and penetrating them to their most remote distribution. The cerebral branches of the organic nervous system are continuous with the cerebral and true spinal nerves, and must be considered as the originators and conductors of all impressions, whether normal or abnormal. The organic branches communicate impressions or emotions of the mind to the cerebral nerves, by which it is conveyed to the cephalic centre, and by reflexed action conveyed back to the tissue or organ first impressed. They perform a similar function in relation to the true spinal

system. Every emotion, every sensation, which takes place in the human organism, must be attended or preceded by a change of matter or force, produced by the organic nervous force. The cerebral nerves can produce no sensation, except by means of the cerebral branches of the organic system. Neither can the true spinal perform any excito-motory function, except by means of the organic branches which are continuous with the inter-communications between the cerebral and true spinal nervous systems, and may produce a reciprocity of stimulation or debility, by which the functions of either one of the three may be increased or diminished.

The organic system can perform its functions independently of either or both the other systems. In support of this may be adduced the well-known cases of monstrosity related by Mr. Lawrence and Dr. Hall. In the interesting case of acephalous monstrosity published by Mr. Lawrence, the brain only was wanting; all the excito-motory functions were duly performed; it gave evidence of pain, and at first moved briskly. The sphincters performed their office. This, of course, was referable to the integrity of the true spinal nerves generally. The child breathed, and its temperature was natural. It discharged urine and feces, and took food; the latter circumstance indicated the operation of the functions of the organic nervous system and its collateral parts, without any aid from the brain. In the remarkable case cited by Dr. Hall, of a fœtus born without either brain or spinal cord, yet perfectly developed, we have a very satisfactory proof of the independence of the organic functions of the cerebral and true spinal nervous system.

The fact has been anatomically demonstrated that the solar ganglion, the centre of the organic nervous system, is formed before the existence of any vascular formation; that branches of the organic nerve surround and penetrate the coats of the bloodvessels to their most minute ramifications; and that they augment in size and increase in number commensurate with the function these vessels are designed to perform in the animal organism.

The cerebral, the true spinal, and the organic nervous systems, regarded separately as the centre of the several nervous systems of man, though executing distinct functions in the economy of life, are, by means of the innumerable ramifications of their subordinate parts, and their union with each other, brought into so close a relation that their physiological separation is impossible. Though they are not dependent mutually, they, nevertheless, exercise such a reciprocity of functions that the health and well-being of man are regarded as inseparable from their union. They may be compared to a tree, the root, the trunk, and the extremities of which may be said to represent them; for the root has been the source, and continues to be the life of the other two; it existed without them, and might again do so, though during their maturity it fails not to be a recipient of their toil. The root will sometimes live without the trunk and its extremities, and so will the paralyzed idiot. The organic nervous system exercises the architectural power which is employed in man and in animals to exhibit the wonderful and suc-

cessive changes which characterize not only intra and extra-uterine existence, but also normal and abnormal actions.

The organic functions in the lower class of animals, which have neither brain nor spinal marrow, are not less completely performed than the same functions in man. Secretion, nutrition, &c., are as elaborately performed in the polypus and oyster as in the mammalia.

The organizing force derived from the spermatozoon of the male, together with the heat and organizable force of the blood of the mother, are subdivided into all the organic affinities and molecular motions which occur in the development of the embryo. At birth all the tissues are formed and the blood in circulation, and as soon as the lungs absorb the atmosphere the organic nervous force becomes the universal and predominant power in the animal organism.

The organic force of the organic nervous system has the same relation to the whole organism that the steam has to the several parts of the engine. The organizing force and the steam are equally the motive power. To their different states must be attributed every kind of change of which the animal organism or the machine itself is under any circumstances susceptible.

The elements of the blood are generated, elaborated, and depurated of their effete constituents by a series of cellular formations and transformations by the organic nervous force, which manifests itself in the form of affinity, nutrition, or attraction, by which each nutritive element is attracted by identical elements in the elementary composition of the tissue of which it is destined to become a component part by cellular formation and coalescence. Every tissue of the organism is, in this manner, formed and nourished by its appropriate element or elements from the blood. It will be observed that I maintain that the blood is formed by the organizing force of the organic nervous system derived from the spermatozoon of the male out of the ovule of the female, which is organizable; that both of these are secretions; that out of these embryotic life is developed; that, when fœtal life terminates at maturity by birth, the organizable matter is furnished by the food of the infant or adult, which is decomposed by the organic force of the organic nerves, and converted into a new compound; that this compound undergoes a series of conversions and elaborations by the organizing force of this nervous system, by which it is converted into the various secretions, tissues, and forces of the animal organism; and that all these changes of organic matter into living organized matter, or into vitality, takes place in the capillary bloodvessels.

That the functions of all the bloodvessels—arterial, venous, and capillary—are generated, controlled, and maintained by the organic nervous system, appears evident from the anatomical fact that the solar ganglion, the centre of the organic nervous system, is formed before the existence of any vascular formation; that branches of the organic nerve surround and penetrate the coats of the bloodvessels to their most minute ramifications into the capillary system; that these vessels have no other nervous endowment; that the

organic nervous branches augment in size and increase in number commensurate with the function these vessels are designed to perform in the human organism, and that this function is independent of that of the cerebral and true spinal nervous systems. These nervous systems impart increased energy to the organic functions, as light, heat, and electricity do to the vegetative.

Pathology teaches us that the organic processes proceed in those parts of the organism in which the cerebral and true spinal nervous systems are paralyzed exactly in the same way as in other parts where these nerves are in a normal condition. Sir B. Brodie shows, by his experiments, that the destruction of the crural and sciatic nerves, and even the lumbar spinal cord, neither retarded nor impaired in any way the reparative processes in the lower extremities; thus, wounds and fractures made in the limbs, deprived of cerebral and true spinal nervous influence, healed and united as readily as under all ordinary circumstances. The organic nervous branches distributed to the extremities were normal, and the organizing force of these branches caused the wounds and the fractures to unite. Many other cases in illustration might be adduced.

Secretion.—The literal meaning of the term secretion is separation. The process of secretion is performed by the agency of *cells*. How complexed so ever the structure of a secreting organ, these simple bodies constitute its operative parts. The process is strictly analogous to that of nutrition, since *every cell* in the progress of its development forms certain peculiar products out of the alimentary materials supplied to it; and just as the cells at the extremities of the villi select from the chyme the nutritive portion which is to be introduced into the absorbent vessels, so do the cells which line the secreting tubuli select from the blood the effete particles which it is their peculiar province to assimilate, and discharge them into the canals by which they will be carried out of the organism. There are not, therefore, two organic processes going on at the same time in the same gland. The only difference between this kind of growth and that which occurs in other organs is that a portion of the product is thrown out of the organism from the anatomical condition of the part. There cannot be a better illustration of this view than the nature of fat, the production of which is exactly the intermediate link required to connect the two processes.

The adipose tissue consists of cells, by the action of which the fatty matter is elaborated from the blood instead of being thrown out of the organism. It remains stored up in their cavities until it is required for use within the organism; and it must then be taken into the circulation by a process resembling the first absorption of aliment.

A certain portion of fatty matter is normally formed in the secreting cells of the liver, and this quantity may be very much increased, as Mr. Bowman has shown, especially in diseases which obstruct the pulmonic circulation. The fat elaborated by the cells is destined to be thrown off from the system;

and thus we perceive how much the anatomical position of the cells have to do with the function of secretion. It can scarcely be questioned that the chief source of the secretion is to be formed in the continued decomposition of the various tissues of the organism. They are derived more from the blood itself than from the fluids returned into the blood by the lymphatics. During the circulation of the blood, it parts with one portion of its constituents in one tissue of the organism by the transformation of the cells containing them, and with another, in a different tissue by a modification of the same process. The abstraction of organizable matter does not occasion any chemical change in the composition of the blood, because the fibrin and red corpuscles which are thus removed are continuously renewed at the expense of the albumen; while of the albumen, a new supply is absorbed by the absorbent system. The elaboration of gelatin, however, which is deposited so carefully in the solid tissues, must produce considerable alteration in the blood, since in its production from albumen a certain residuum must be left. This residuum is, probably, another source of the products of secretion. In several other instances, peculiarities of secretory action in different tissues will deprive the blood which passes through them of its due proportion of certain of its elements; these are partly restored by its admixture in the heart with the blood which has been returned from other parts; but still a general alteration in the character of the blood is the result of its circulation. For this alteration it is the province of the secretory functions to compensate.

A striking illustration may be found in the change of colour, and in the proportional amount of free oxygen and carbonic acid, which take place in the systemic capillaries by the normal transformations of the cells containing the elements of the blood. Hence it may be regarded as a physiological fact that no chemical change can be produced in the products of any secretory process except by a chemical change in the elementary constituents of the blood in that tissue by means of their cellular mutations. Medicinal agents must, therefore, induce cellular formations and transformations in the elementary constituents of the blood in the capillaries in any gland or tissue, before they can chemically change the products of the secretory function of that gland or tissue. No therapeutical agent can produce any effect unless it chemically alters the elementary composition of the blood. This is the only mode by which medicinal agents can act therapeutically.

The *heart* is a muscular organ. It is usually regarded as the motive power of the circulation. But no physiological fact is more clearly proved than the existence in the lower classes of animals, as well as in plants, of some power independent of the *vis à tergo*, by which the circulating fluid in man is caused to move through the vessels. This power seems to originate in these ultimate tissues, and to be closely connected with the state of the nutritive and secretory processes, since anything which stimulates them to increased energy accelerates the circulation, while any check to them occasions a corresponding stagnation.

For convenience, this motor force may be called *organic nutritive attraction.* The movement of the blood through the capillaries is in a great degree, if not entirely, independent of the action of the heart; since it may continue after the heart's action may itself cease in particular organs, when the heart itself is still acting vigorously; and it is constantly affected in amount and rapidity by causes originating in the part itself, and in no way affecting the heart. The movements of the blood in the capillaries of cold-blooded animals after complete excision of the heart have been repeatedly observed. In warm-blooded animals this cannot be satisfactorily established by experiments, since the shock occasioned by so severe an operation much sooner destroys the organic nervous force.

After most kinds of natural death, the arterial system is found, after the period of a few hours, almost or completely emptied of blood; this is partly the effect of the contraction of the arteries themselves; but the emptying is usually more complete than could be thus accounted for, and must, therefore, be due to the continuance of the capillary circulation. When death takes place suddenly from such a cause as an electric shock, which destroys the organic nervous force of the whole organism, the arterial tubes are found to contain their due proportion of blood. It has been well ascertained that a true process of secretion not unfrequently continues after the cessation of respiration, and the action of the heart and arteries. Urine and perspiration have been secreted, and other peculiar secretions formed in the glands. These changes could not have taken place unless the capillary circulation were still continuing. In the early embryonic condition of the highest animals, the movement of the blood is unquestionably due to some diffused power independent of any central impulsion; for it may be seen to commence in the vascular area before the development of the heart. The first movement of the blood is towards the central organ, or heart, instead of from it; and even for some time after the circulation is fairly established, the walls of the heart consist merely of vesicles loosely attached together, and, therefore, cannot have any great contractile power.

Cases are of no unfrequent occurrence in which the heart is absent during the whole of embryonic life. We have described the origin and development of the organic nervous force. We have shown that it is created prior to the heart, and that it controls and regulates the early embryonic circulation before the central organ is formed. It is the formative and controlling force of every tissue in the organism. It is to the organism what the steam is to the engine. The heart is a muscular organ of wonderful mechanism; its power is derived from the organic nervous system by its organizing force in the production and transformation of the cells upon which the muscular action of the heart depends. Without the creation and disintegration of these cells, the heart could not act. Its muscular contractions and relaxations are accelerated or diminished, weak or strong, in direct proportion to the force of the organic nervous system in the mutations of its histological cells. The heart affords

the organic nervous system the mechanical apparatus necessary for the propulsion of the blood from it into the arterial vessels. There is a constant change going on in the cells of which the blood is composed. When the blood is carried into the capillaries of the lungs, the cells containing its elementary constituents are rapidly formed and transformed.

The Lungs.—Whatever may be the view entertained of the ultimate structure of the lungs, there is no difference in opinion as to the main physiological fact that these organs consist of a congeries of minute air-cells, whose cavities are capable of dilatation and contraction, and on whose walls a very minute plexus of capillary bloodvessels is distributed. The air-cells and air-tubes are endowed with a considerable amount of contractility, which resembles that of the intestines or arteries, and by which the absorption of oxygen from the atmosphere and the secretion of carbonic acid gas from the blood are favoured; because it enables the air-cells to receive and retain more resident oxygen within these cavities, which greatly facilitates the absorption and combination of this gas with the carbon of the blood by its continued approximation to and gentle pressure upon the minute absorbent cells in the ultimate glandular structure of the lungs. The production of cells as an integral part of absorption or secretion has been demonstrated by Mr. Goodsir in a variety of experiments; and he has further shown that what is ordinarily termed an acinus is nothing more than a parent-cell filled with progeny. This statement may be applied to the lungs in which the air-tubes do not terminate in a dilated sac, but open into a system of communicating beaded canals forming a kind of acinus. These beaded canals are evidently composed of cells partly fused together; and, by the comparison of their state in animals of different ages, it seems that they are all developed from the cell in which the air-tube terminates, and that they continue to increase in number from the period of their birth to adult age. The fact respecting the function of the red corpuscles of the blood and their connection with the respiratory function, supplies the required proof that respiration takes place through the medium of cells. Respiration is a process of absorption and of secretion, and governed by the same laws by which these processes are in the other glands of the organism.

Arteries.—Every manifestation of organic nervous force must take place in the capillaries. That the movement of the blood through the arterial vessels in man is, in a great degree, dependent upon the mechanical action of the heart, there can be no doubt. But the bloodvessels have an influence in producing both local and general modifications of the effects of the heart's action. The middle or fibrous coat of the arteries is alone endowed with contractile properties. The arteries have the same organic nervous endowment as the heart. They have vascular and nervous branches of the organic system which control and regulate their functions in the organism, and bring them in relation to the external world. The fibrous coat of the arteries is endowed with muscular branches of the organic nerve, which causes it to contract and relax alternately like the walls of the heart, but not in a manner so manifest,

because the fibres are shorter, and the organization of the adjacent tissues is different.

The force of these alternate contractions in the fibrous coat of the arteries is supplementary to that of the heart's impulse relaxing to receive the blood from it, and contracting upon their contents with a power superior to that by which they are distended. The muscular coat regulates the diameter of the arteries in accordance with the quantity of blood to be conducted through them to any organ or tissue. Local changes are continually to be observed in the various phases of normal life as well as in diseased states; and they will be found to be in harmony with the particular condition of the processes of nutrition, secretion, &c., to which the capillary circulation ministers. Of this kind, are the enlargement of the trunks of the uterine and mammary arteries at the periods of pregnancy and lactation; the enlargement and strongly increased pulsations of the radial artery when there is any active inflammation in the thumb; the enormous diameter to which the spermatic artery will attain when the testicles is greatly increased in size by diseased action. This dilation is due to increased nutrition in the coats of the arteries, since we find that their walls are thickened as well as distended.

Capillaries.—We have already indicated the independence of the capillary circulation of the heart's action. In an acardiac fœtus the heart is never formed, yet the organic nervous force manifested in the capillaries in the form of nutritive attraction supplies its place up to the period of birth, after which the circulation ceases for want of due aeration of the blood. The capillaries may, by excessive and perverted nutrition, afford a complete check to the circulation in a part, even when the heart's action is not impaired, and no mechanical impediment exists to the transmission of the blood. Thus, cases of spontaneous gangrene of the lower extremities are of no unfrequent occurrence, in which the death of the solid tissues is clearly connected with a local decline of the circulation; and an examination of the limb, after its removal, shows that both the large tubes and capillaries were completely pervious; so that the cessation of the flow of blood could not be attributed to any impediment except the destruction of some force which existed in the capillaries, and is necessary to the maintenance of the current through them.

Normal reaction between the blood and surrounding medium, whether this be air, water, or solid organized tissue, is a condition necessary to the regular movement of the blood through the capillaries. When the ordinary respiration of an animal is interrupted, and the asphyxia is proceeding to the state of insensibility, the first lesion induced is that of organic innervation, which produces a lesion of circulation, the blood accumulates so as to distend the arteries, even though it is at the time nearly venous in its character. This indicates that the fluid, now so perverted, is unable to pass with facility through the systemic capillaries, because the organic nervous force has lost its controlling influence over the elements of the blood. The elements are not normally transformed; oxygen is neither normally absorbed, nor carbon nor-

mally secreted. An accumulation of blood in the venous system, and a deficient supply of arterial, are the necessary consequences. When the blood is not normally arterialized, it has a depressing influence upon the brain and organism generally, because its cells containing its different elements cannot undergo normal transformation by which they would form component elements of the different tissue, or be depurated from the organism.

It is a general fact, unquestioned by any physiologist, that when there is any local excitement to the processes of nutrition, secretion, &c., a determination of blood towards the part speedily takes place, and the motion of the blood through it is increased in rapidity; and, although it might be urged that this increased determination may not be the effect but the cause of the increased local action, such an opinion cannot be sustained. Local determination may take place, not only as a part of the regular phenomena of growth and development, as in case of the entire genital system at the period of puberty, but also as a consequence of a strictly local cause. All these facts harmonize completely with the phenomena which are yet more striking in the lower classes of organized beings, and are evidently the result of the same law. The capillaries are endowed with an organization analogous to that of the arteries; they appear to be a more delicate and highly organized prolongation of the same tissue. That the contractile coat of the capillaries is largely endowed with organic nervous branches, which control and regulate their calibres, scarcely admits of doubt. Local stimulants produce a contraction of the capillaries by their action upon the organic nervous branches distributed into their coats. The effect of stimulants is to accelerate the capillary circulation, unless an abnormal condition of the organic nervous branches results from their sudden or continued influence. While the introduction of blood into the capillaries of every tissue of the organism is facilitated by the action of the heart, its rate of passage through these vessels is generally modified by the degree of activity in the processes to which it should be normally subservient in them. The current flows more rapidly by an increase in their activity, and becomes stagnated by its depression or total cessation. The capillaries possess a distributive power over the blood, regulating the local circulation independently of the heart, in obedience to the function of each gland or tissue. The dilatation and contraction of the capillaries have only a secondary influence on the movement of the blood through them; the primary is derived from the organic nervous system.

A gentle stimulant, which excites the contractility of the capillaries, accelerates the motion of the blood by rendering more energetic the cellular formation and transformation of its elements, and the combination of its nutritive elements with the surrounding tissues. The combination of the nutritive elements with the adjacent tissues is in obedience to the laws of organic nutritive attraction, and any abnormal influence which impairs this attraction impairs the nutrition of the tissues in which these capillaries circulate, because it impedes the cellular mutations of the elements of the blood upon which the normal nutri-

tive attraction for the surrounding tissues depends. When the elements of the blood do not undergo normal mutations, they may be attracted towards the solid tissues surrounding the capillaries; but, as they do not undergo that series of cellular changes which completely liberates the nutritive elements from the effort, they are to some degree repelled by the solid tissues, because these tissues attract nutritive elements strictly in obedience to the laws of their ultimate elementary composition. Alterations in the chemical condition of the blood are, therefore, caused by a lesion of organic innervation, and produce a lesion of capillary circulation by which the elements of the blood aggregate in obedience to the laws of chemical affinity. This proposition enables us to comprehend the magnitude of morbid action produced in the whole organism when the lungs fail to absorb a normal quantity of oxygen, or secrete a normal quantity of carbonic acid gas; when the liver fails to secrete normally its carbonaceous compounds; or the kidneys, the effete azotized elements of the transformed tissues. When all these depuratory glands at the same time fail to perform their normal functions, the blood is soon rendered unfit for the purposes of the organism; a diseased transformation of all the tissues of the organism is produced.

ART. VII.—*On Incontinence of Urine in Children.* By D. D. SLADE, M. D., of Boston.

INCONTINENCE of urine in children is one of those affections with which the practitioner constantly meets, and although in general it is one of no serious character, yet it often proves extremely rebellious to all treatment, and becomes exceedingly annoying to the medical man, not only from its obstinate persistence, but from the very fact of its apparent insignificance.

The discharge of the contents of the bladder and rectum take place involuntarily in early infancy; but as the child advances in age it acquires a control over the sphincters, being prompted to this by a sense of decency as well as by other influences. The involuntary discharge of the contents of the bladder may, however, from a variety of causes, be kept up to the age of puberty, and even later, proving a source of inconvenience and extreme mortification to the unhappy subject of it.

We shall arrange these children who suffer from incontinence of urine into three classes. In the first class, the affection is constant and due to special causes which need not occupy our attention here. In the second, it is intermittent in its character, occurring in the day as well as in the night; while in the third class it is nocturnal only.

In the second of these classes, which constitute cases by no means rare, and much less amenable to treatment than those where the affection is only